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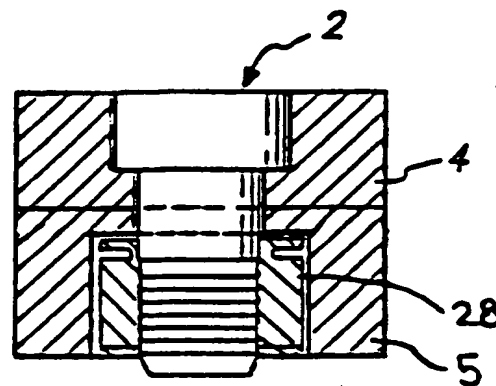
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(54) Title: OPTIMIZED ELASTIC FASTENER USEFUL IN EYEGLASS FRAMES

## (57) Abstract

A fastener (2) useful for attaching components of an eyeglass frame together. The fastener includes a pin (6) having a smooth or fluted shank (9) and a retainer (3 and 28) having a hole for receiving the shank, the hole being sized to provide an interference fit with the shank. The retainer (3 and 28) is made from a titanium nickel shape memory alloy in an optimized elastic condition. The optimized elastic condition is provided by work hardening a tube or wire of Ni-Ti and cutting the retainer out of the tube/wire. The retainer accommodates wear in moving parts held together by the retainer and pin assembly.



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## OPTIMIZED ELASTIC FASTENER USEFUL IN EYEGLASS FRAMES

### Field of the Invention

The present invention relates to fasteners used in eyeglass frames for holding lenses into lens frames and temple pieces to the lens frames and hinges.

### 5 Description of Related Art

Historically small screws have been used to attach various eyeglass frame components together to form a completed frame. Screws specifically are used to attach temple pieces at the hinge to lens frames. They are also used to tension and anchor or lock lenses into lens frames allowing assembly and  
10 disassembly for replacement of lens or damaged components or initial shipping of frames with demonstration lenses in place.

In normal use eyeglass frames are subjected to stresses and strains in a cyclical manner that tend to loosen screws and wear the threads with which the screws are mated resulting in temple pieces becoming loose or detached and  
15 lenses falling out of their frames.

Various methods to minimize this problem have been tried with limited success. Examples are polymeric compounds often referred to as "locktite" intended to at least slow down the loosening process. This method requires individual coating of the screws which is expensive and provides only limited  
20 improvement over uncoated screws eventually succumbing to the same process of loosening. Another example of a method intended to "lock" the screws in place is the use of distorted threads on the screw to create a mechanical jamming action with the mating threads. This method offers only limited improvement again eventually succumbing to the loosening process as well.  
25 Both methods make any replacement or disassembly and reassembly process difficult or impossible and do not accommodate wear of the mated components even if no loosening or backing out of the screws occurs.

U.S. Patent No. 4,896,955 ("the '955 patent"), the subject matter of which is hereby incorporated by reference, discloses an eyeglass frame, of  
30 which components are formed from nickel-titanium based shape memory alloys.

- 2 -

Components of the frame can be formed from such alloys treated in a variety of ways, to confer desired properties on the component. For example, fastening elements used in the frame can exhibit conventional shaped memory properties of the alloy. Other components of the frame can exhibit the enhanced elastic properties exhibited by shape memory alloys.

A shape memory alloy can exhibit "super elastic" behavior at a temperature below the  $M_s$  of the alloy as a result of a significant degree of work-hardening, for example to about 30% or more plastic deformation. By selection of an alloy with an appropriate  $M_s$  temperature, with appropriate work-hardening, such behavior can be obtained in a temperature range of -20°C to 40°C.

A shape memory alloy can exhibit "pseudo-elastic" properties. Such properties are exhibited in a narrow temperature range, between the  $M_s$  and  $M_d$  temperatures of the alloy. They involve transformation of an alloy in its austenite phase to its martensite phase by the application of stress. Application of stress in these conditions can give rise to high strain values. Provided that the temperature is between the  $M_s$  and the  $M_d$  temperatures of the alloy, virtually all of the strain is recovered. The deformation and recovery are marked by significant deviations from linear elastic behavior.

A shape memory alloy which has been work-hardened, perhaps to 30% or more plastic deformation, and at a temperature between its  $M_s$  and  $M_d$  temperature, exhibits a combination of superelastic and pseudoelastic behavior known as "optimized elastic" behavior. The optimized elastic behavior is referred to in the '955 patent as "work-hardened pseudoelastic" behavior.

It is advantageous to use shape memory alloys which exhibit enhanced elastic behavior in the manufacture of eyeglass frames, for their kink resistance. Pseudoelastic properties are particularly preferred, because of the large amount of strain which can be recovered. However, a disadvantage of relying on pseudoelastic properties is that they are available only over a narrow temperature range.

- 3 -

This problem was addressed in the '955 patent by subjecting shape memory alloy eyeglass frame components to work-hardening. In this way, the advantages of superelastic behavior, and some of the advantages of pseudoelastic behavior can be obtained from temperatures below the  $M_s$  temperature up to the  $M_d$  temperature of the selected alloy.

### SUMMARY OF THE INVENTION

The invention provides a fastener comprising a pin and a retainer. The pin includes a shank and the retainer includes a hole therethrough extending between opposite sides of the retainer, the hole being sized to provide an interference fit with the shank. In addition, the retainer is of a titanium-nickel shape memory alloy in an optimized elastic condition. The optimized elastic behavior provides a degree of tightening heretofore unavailable while minimizing the need for tight tolerances and while compensating for wear of components held together by the fastener.

The pin can include a flange extending radially outwardly from one end of the shank and the other end of the shank can be tapered to facilitate entry in the hole of the retainer. The retainer can include a portion which is conical in shape such that the entire conical surface extending between the hole and an outer periphery of the retainer is inclined with respect to a normal to a central axis passing through the hole. For instance, the conical surface can be inclined at an angle of at least  $10^\circ$  with respect to the normal to the central axis. The shank can be provided with a smooth or irregular outer surface. For instance, the irregular surface can comprise a plurality of axially spaced-apart indentations extending circumferentially around the shank and the indentations can be concave in axial cross section. The hole is preferably circular and the shank is preferably cylindrical, the hole being sized to have a diameter smaller than a maximum outer diameter of the shank.

According to one feature of the invention, the fastener can be used to hold together components of an eyeglass frame. For instance, the shank of the pin can extend through axially aligned bores in two discrete components of an

- 4 -

eyeglass frame such that the retainer is press fitted on the shank and prevents the two components of the eyeglass frame from being removed from the pin. Alternatively, in the case where the pin forms part of a component of an eyeglass frame, the shank of the pin can extend through a bore in another component of the eyeglass frame and the retainer can be press fitted on the shank to prevent the component from being removed from the pin. The optimized elastic behavior of the retainer can be utilized over a temperature range of  $-20^{\circ}\text{C}$  to  $+40^{\circ}\text{C}$ , the range of temperatures most eyeglass frames are subjected to when in use.

10

### **BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 is a cross-sectional view of a fastener in accordance with the invention;

FIG. 2 is a perspective view of a pin which can be used as part of the fastener in accordance with the invention;

15

FIG. 3 is a detail drawing showing a fluted surface on the pin shown in FIG. 2;

FIG. 4 is a perspective view of another pin which can be used in accordance with the invention;

20

FIG. 5 shows a top view of a belleville washer in its as manufactured condition which can be used as part of the fastener in accordance with the invention;

FIG. 6 shows a side view of the washer shown in FIG. 5;

FIG. 7 shows a side view of the washer shown in FIG. 6 subsequent to a shaping step wherein the washer is given a conical shape;

25

FIG. 8 is a schematic drawing of an installation tool for assembly of fastener of the invention;

FIG. 9 shows an eyeglass frame in which the fastener according to the invention can be used;

30

FIG. 10 is a cross-sectional view of another fastener in accordance with the invention;



- 5 -

FIG. 11 shows the retainer of FIG. 10 in an uncompressed state; and  
FIG. 12 shows the retainer of FIG. 10 in a compressed state.

### **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

5 The invention provides a fastener which can be used to replace threaded screws for eyeglass components with the advantage of eliminating the loosening and wear typical of screws. The fastener according to the invention allows positioning, tensioning and locking with the added advantage of being capable of being disassembled and reassembled at will.

10 According to one aspect of the invention, the fastener includes a flanged pin and mating "optimized elastic" Ni-Ti based alloy retainer. The mating diameters of the pin and hole in the retainer are preferably sized to provide an interference fit with the leading end of the pin preferably being tapered to allow alignment and initial entry into the retainer. To provide enhanced gripping, the pin can include flutes along the length thereof. However, adequate gripping  
15 between the pin and retainer can be obtained when the pin is smooth along the length thereof. Through the use of a simple tool, the pin and retainer can be adjusted relative to each other to provide a desired tension and/or position. The tool advances the pin into the retainer and spring loads the "optimized elastic" Ni-Ti based alloy retainer against a part such as a lens frame or hinge  
20 component of an eyeglass frame.

As the eyeglass frames are subjected to the usual cyclical stresses and strains in normal use, the extraordinary elasticity of the optimized elastic Ni-Ti alloy retainer will maintain a fairly uniform spring loading on the joined components even as wear occurs in the sliding surfaces of the components.

25 Another simple tool can be used to disassemble the pin/retainer combination. The disassembly tool should be capable of pressing the pin out of the retainer. For example, by removing the pin, the eyeglass frame components can be separated from each other. Subsequently assembly can be accomplished using the same components or a new pin and retainer set by the  
30 method noted above.

- 6 -

A fastener according to one embodiment of the invention will now be described with reference to FIGS. 1-9. In particular, the invention provides a fastener 1 including a pin 2 and retainer in the form of washer 3, as shown in the assembled condition in FIG. 1. According to a preferred use of the invention, the pin 2 and washer 3 can be used to hold a first component 4 and a second component 5 of an eyeglass frame together. Further, the washer 3 preferably has the conical shape shown in FIG. 1 and the washer 3 can be pressed against the component 5 such that the washer 3 either maintains the conical shape or is flattened completely against the component 5.

As shown in FIG. 2, the pin 2 includes a shank 6 and the pin 2 can include a tapered end 8 and a radially outwardly extending flange 7. If desired, the outer surface of the shank 6 can have an irregular surface 9. FIG. 3 is a detail of the irregular surface shown in FIG. 2. As shown in FIG. 2, the irregular surface 9 can comprise a plurality of axially spaced-apart indentations 10 extending circumferentially around the shank. As shown in FIG. 3, the indentations can be convex in axial cross-section. Alternatively, the shank 6 can have a smooth surface 11, as shown in FIG. 4. In addition, the flange 7 can optionally include a slot or socket 12 to facilitate mounting of the pin 2 on a tool used for inserting the pin 2 in a bore through a component.

The washer 3 includes a hole 13 having a diameter smaller than an outer diameter of the shank 6. When the washer 3 is press fitted onto the shank 6, the edge of the washer 3 defining the hole 13 is elastically deformed such that it is expanded and tightly grips the outer surface of the shank 6. The washer is made from a titanium-nickel based shape memory alloy in an optimized elastic condition. The optimized elastic condition can be provided by work hardening a sheet of Ni-Ti at temperatures between the  $M_s$  and  $M_d$  of the alloy. Subsequently, the washer 3 can be stamped or cut out of the sheet, the hole 13 can be stamped in the washer 3 and the washer 3 can be deformed from the flattened condition shown in FIG. 6 to the conical shape shown in FIG. 7. As shown in FIG. 7, the washer 3 includes a conical surface extending between the hole 13 and the outer periphery of the washer 3. The conical surface 14 forms

- 7 -

an angle with a normal to a central axis of the hole 13. The angle is preferably greater than  $10^\circ$  and more preferably ranges from  $15$  to  $30^\circ$ .

FIG. 8 shows an insertion tool 15 for press fitting the washer 3 onto the shank 6 of the pin 2. The tool 15 includes a displaceable centering pin 17  
5 movable in an axial direction and sized to pass through the hole 13 in the washer 3. The centering pin 17 can be mounted on a spring 18 and the spring 18 and centering pin 17 can be located in a socket 16 of the tool 15. The tool also includes a washer supporting surface 19 which surrounds the centering pin 17 and is sized to surround the shank 6 of the pin 2 when the washer 3 is press  
10 fitted onto the shank 6 of the pin 2. The washer support surface 19 can be annular in shape and perpendicular or inclined to the axial direction. Thus, when the washer 3 is press fitted onto the shank 6 of the pin 2, the edge of the washer 3 defining the hole 13 is expanded over the outer surface of the shank 6 until the washer 3 contacts the component 5. The washer supporting surface 19  
15 or a separate tool can be used to deform the conically shaped washer 3 such that it is flattened against the component 5.

The fastener according to the invention can be used to hold together the components of eyeglasses 20, shown in FIG. 9. Eyeglasses 20 comprise temples 21 and 22, and frame 23 supporting lens 24 and lens 25. Temples 21  
20 and 22 are joined with frames 23 at hinges 26 and 27 by fasteners according to the invention.

The Ni-Ti material of the washer 3 may or may not include one or more alloying elements. In addition, the material of the washer 3 can optionally be subjected to heat treatment provided the material of the washer 3 retains some  
25 work hardening. In forming the conical shape of the washer 3, a flat washer 3, as shown in FIG. 6, can be placed in a die having a conical shape. Due to springback, the conical shape of the die should be more tapered than the desired conical shape of the washer 3. For instance, in order to obtain a taper of  $15$  to  $20^\circ$  in the final conical shape of the washer 3, the die can be provided with a  
30 taper of over  $30^\circ$  such as about  $45^\circ$ . Thus, when the washer 3 is pressed into

- 8 -

the die, to form the conical shape upon release of the deforming force the washer 3 will spring back to a conical shape having the desired angle.

The pin 2 can be of any suitable material which provides an interference fit with the washer 3. For instance, the pin 2 can be a copper based alloy such as BeCu, a steel such as stainless steel or hardened tool steels, or other material with similar strength characteristics. The pin 2 and washer 3 can have various dimensions and shapes provided they can be assembled together to provide an interference fit. For example, the pin 2 can include a shank 6 having an outer diameter of 0.053" and a radially outwardly extending flange 7 having an outer diameter of 0.073". The washer 3 can be conical in shape such that surfaces 14 of the washer 3 form an angle with a normal to the central axis of the hole 13 in the washer 3. In a flattened condition, the hole 13 in the washer 3 should be smaller than the outer diameter of the shank 6 of the pin 2. For example, if the shank 6 has an outer diameter of 0.053" the hole 13 can have a diameter of 0.049".

A fastener according to another embodiment of the invention will now be described with reference to FIGS. 10-12. In particular, the invention provides a fastener including a pin 2 and retainer 28, as shown in the assembled condition in FIG. 10. According to a preferred use of the invention, the pin 2 and retainer 28 can be used to hold a first component 4 and a second component 5 of an eyeglass frame together. Further, the retainer 28 preferably has the conical shape shown in FIG. 11 in the uncompressed state whereby when the retainer 28 is pressed against the component 5 the conical shape is flattened somewhat or completely against the component 5, as shown in FIG. 10.

FIG. 11 shows the retainer 28 in the uncompressed state. The retainer 28 includes a body portion 29 and a spring portion 30, the spring portion 30 being elastically deformable in a direction towards the body portion 29. The spring portion 30 and the body portion 29 can be integral and of a single piece of material. The spring portion 30 can comprise a conically shaped belleville washer similar to washer 3 in the first embodiment of the invention. The body

- 9 -

portion 29 and spring portion 30 are separated by a groove 31. The groove 31 extends radially inwardly and separates an outer periphery of the body portion 29 from an outer periphery of the spring portion 30. The groove can be V-shaped and can form an angle of 5 to 45°, preferably 10 to 20°.

5           FIG. 12 shows retainer 28 in the compressed state. As shown in FIG. 12, spring portion 30 is elastically deformed towards body portion 29.

          The optimized elastic property of the washer 3 and retainer 28 in combination with the pin 2 maintain a resilient compression in the hinge assembly capable of accommodating wear in the hinge assembly. For instance,  
10       the fastener according to the invention can accommodate as much as 0.08 mm of wear in an eyeglass hinge assembly. The fastener also allow precise initial setting of the hinge "feel" and post-adjustment for excessive wear or user preference. Moreover, the pin and retainer/washer can be easily installed and removed.

15           The retainer 28 can be used with a stainless steel pin similar in dimensions to a standard screw without threads. The retainer 28 can be made from a SE 508 NiTi alloy. Due to the construction of the retainer, the retainer can provide an approximately constant force resilient compression of the hinge assembly to compensate for wear over time and use. The cylindrical body  
20       portion 29 of the retainer 28 provides a high gripping force on the pin. In particular, the retainer 28 can be pressed onto the pin with an interference fit (e.g., the retainer 28 can have a diameter 0.05 to 0.07 mm smaller than the diameter of the pin) and the SE 508 alloy can accommodate the pin due to its extraordinary elastic properties. On the other hand, other conventional eyeglass  
25       fastener materials would yield or break or require unachievable tolerance control for this function. Advantageously, the elastic properties of the SE 508 material exhibit approximately constant stress over the strain range of 2% to 6% whereby the gripping forces are approximately constant across the tolerance range for the pin and retainer. The gripping force or radial forces provided by  
30       the retainer can be specifically designed for the intended application.

- 10 -

The spring portion 30 of the retainer provides a resilient spring force to the eyeglass frame element between the head of the pin and the retainer. The geometry of spring portion 30 simulates the belleville washer described earlier in connection with the first embodiment of the invention. However, the  
5 retainer 28 offers the additional advantage of providing an aesthetic flush pin top and flush retainer bottom geometry, as shown in FIG. 10.

The retainer 28 can be machined out of tubing or solid wire. In the case of solid wire, the central core of the wire is drilled out to a diameter which will provide the desired interference fit. In order to provide the elastic portion, the  
10 workpiece is side cut with a screw machine. If necessary, the workpiece can be heat treated to relieve stresses imparted in the machining operation. With respect to dimensions of retainer 28, the spring portion 30 can have a thickness of 0.010 to 0.015", the body portion can have a length of about 0.040", the hole passing axially through the retainer can have a diameter of about 0.053"  
15 and the angle between the spring portion and the body portion can range from 15 to 20°. Also, the end of the body portion opposite to the end facing the spring portion can be provided with an outer rim defining an annular recess for receiving a tool used to assemble or disassemble the retainer on the pin.

The foregoing has described the principles, preferred embodiments and  
20 modes of operation of the present invention. However, the invention should not be construed as being limited to the particular embodiments discussed. Thus, the above-described embodiments should be regarded as illustrative rather than restrictive, and it should be appreciated that variations may be made in those embodiments by workers skilled in the art without departing from the  
25 scope of the present invention as defined by the following claims.

- 11 -

**WHAT IS CLAIMED IS:**

1. A fastener comprising a pin and a retainer, the pin including a shank and the retainer including a hole extending between opposite sides of the retainer, the hole being sized to provide an interference fit with the shank and  
5 the retainer being of a titanium-nickel shape memory alloy in an optimized elastic condition.
2. The fastener of Claim 1, wherein the pin includes a flange extending radially outwardly from one end of the shank.
3. The fastener of Claim 1, wherein the retainer includes a conical  
10 surface extending between the hole and an outer periphery of the retainer, the conical surface being inclined with respect to a central axis passing through the hole.
4. The fastener of Claim 3, wherein the conical surface is inclined at an angle of at least 10° with respect to a normal to the central axis.
- 15 5. The fastener of Claim 1, wherein the shank has a smooth outer surface.
6. The fastener of Claim 1, wherein the shank has an irregular outer surface.
7. The fastener of Claim 6, wherein the irregular surface comprises a  
20 plurality of axially spaced-apart indentations extending circumferentially around the shank.
8. The fastener of Claim 7, wherein the indentations are convex in axial cross section.

- 12 -

9. The fastener of Claim 1, wherein the hole is circular and the shank is cylindrical, the hole having a diameter smaller than a maximum outer diameter of the shank.

5 10. The fastener of Claim 1, wherein the shank of the pin extends through axially aligned bores in two discrete components of an eyeglass frame, the retainer being press fitted on the shank and preventing the two components of the eyeglass frame from being removed from the pin.

10 11. The fastener of Claim 1, wherein the shank of the pin extends through a bore in a component of an eyeglass frame, the retainer being press fitted on the shank and preventing the component of the eyeglass frame from being removed from the pin.

12. The fastener of Claim 1, wherein the shank has a free end which is tapered such that the shank becomes smaller in diameter in a direction towards the free end of the shank.

15 13. The fastener of Claim 1, wherein the retainer includes a body portion and a spring portion, the spring portion being elastically deformable in a direction towards the body portion.

14. The fastener of Claim 13, wherein the spring portion and the body portion are integral and of a single piece of material.

20 15. The fastener of Claim 13, wherein the spring portion comprises a conically shaped belleville washer.

16. The fastener of Claim 13, wherein a radially inwardly extending groove separates an outer periphery of the body portion from an outer periphery of the spring portion.

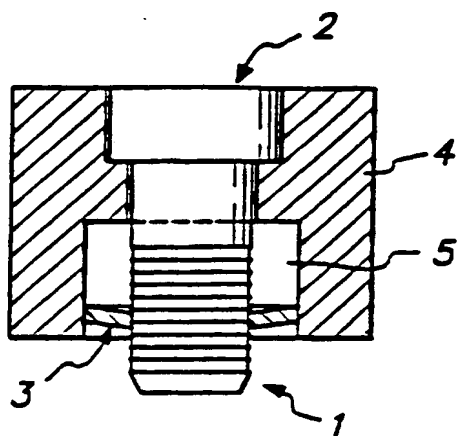


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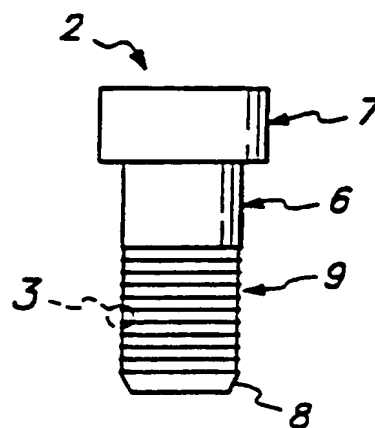
17. The fastener of Claim 13, wherein a V-shaped groove between the spring portion and the body portion forms an angle of 5 to 45°.

18. The fastener of Claim 13, wherein a V-shaped groove between the spring portion and the body portion forms an angle of 10 to 20°.

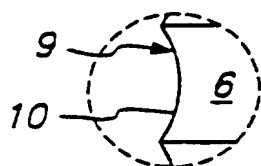
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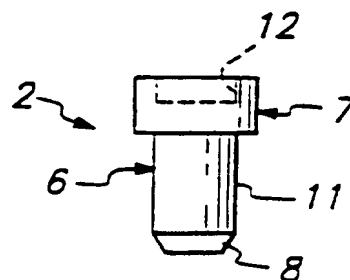
**FIG. 1**



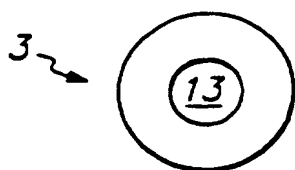
**FIG. 2**



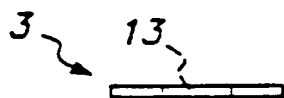
**FIG. 3**



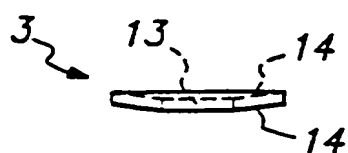
**FIG. 4**



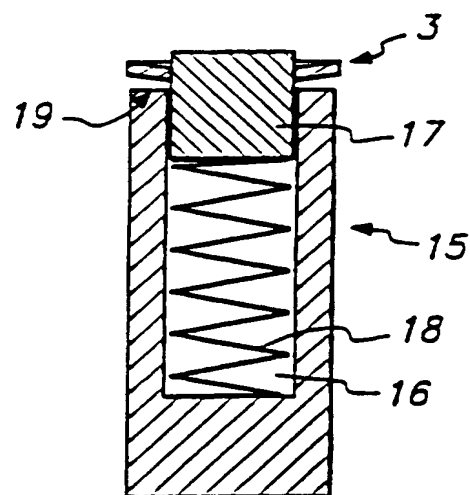
**FIG. 5**



**FIG. 6**

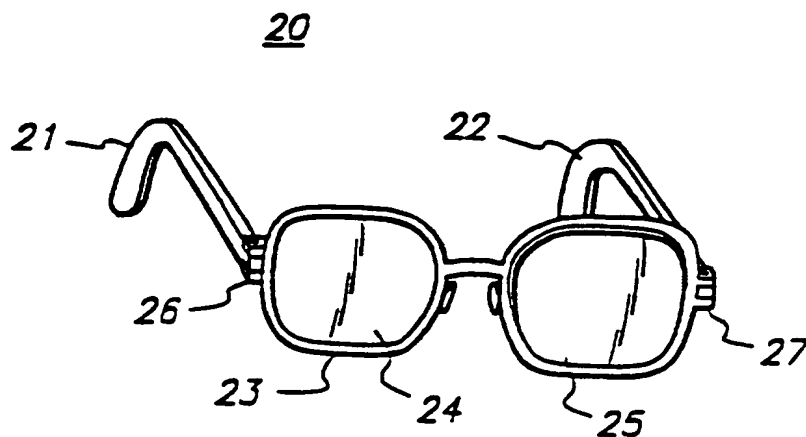
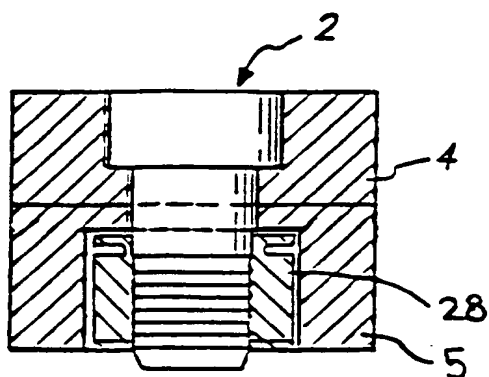
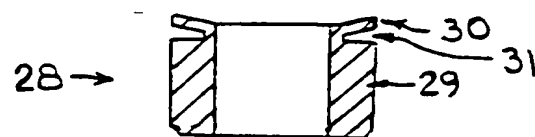
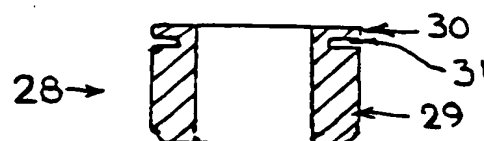


**FIG. 7**



**FIG. 8**

2/2

**FIG. 9****FIG. 10****FIG. 11****FIG. 12**

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US96/02991

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : F16B 21/00, 21/18

US CL : 411/339, 353, 517, 909

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 411/338, 339, 353, 517, 521, 525, 526, 533, 544, 909

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 4,880,343 (MATSUMOTO) 14 NOVEMBER 1989	1-18
A	US, A, 4,450,616 (MORITA) 29 MAY 1984	1-18
A	US, A, 3,619,478 (STALGER) 09 NOVEMBER 1971	1-18
A	US, A, 3,367,228 (KING, JR.) 06 FEBRUARY 1968	1-18

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*A* document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
*E* earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*Z* document member of the same patent family
*O* document referring to an oral disclosure, use, exhibition or other means	
*P* document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

01 JULY 1996

Date of mailing of the international search report

30 JUL 1996

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